Comparing Hemodynamic Symptoms and the Level of Abdominal Pain in High- Versus Low-Pressure Carbon Dioxide in Patients Undergoing Laparoscopic Cholecystectomy

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Abstract The laparoscopic cholecystectomy (LC) is the gold standard to treat gallstone. To view the surgical site in this type of operations better, carbon dioxide is used with a certain pressure. The current study aimed to compare the hemodynamic symptoms and the level of abdominal pain due to using high- and low-pressure carbon dioxide in patients undergoing LC. The current double-blind randomized clinical trial was conducted on 60 patients with the age range of 20–70 years old undergoing LC. The first and second groups experienced PaCO₂ of 7–10 and 12–14 mmHg, respectively. The hemodynamic symptoms, abdominal pain, shoulder-tip pain, nausea and vomiting after the surgery, and the mean of liver function tests were evaluated. Data were analyzed using *T* test, Chi-square test, and repeated measures ANOVA by SPSS 16. Information of 60 patients in two groups was analyzed. There was a significant difference between the groups regarding the mean of systolic blood pressure ($P < 0.05$). The mean of heart rate was significantly higher in the high-pressure group during surgery and 1 h after that ($P < 0.05$). The frequency of pain in shoulder-tip and abdomen was higher in the high-pressure group. Frequency of nausea and vomiting 12 h after the surgery between two groups was significant ($P < 0.05$). The mean of alkaline phosphatase was higher in the low-pressure group than the high-pressure group ($P < 0.05$). Considering the good performance and low side effects of low-pressure laparoscopic cholecystectomy compared to those

of high-pressure, this method can be replaced by high-pressure in LC.

Keywords Laparoscopic cholecystectomy · Low-pressure pneumoperitoneum · High-pressure pneumoperitoneum · Gallstone

Introduction

The gallstone is a common complication of biliary tract, and since 1882 surgery is the best common traditional method to remove it [1, 2]. Almost 10 % of the population has gallstones, and cholecystectomy is the most common surgical method to treat it in the Western countries [1].

However, today, the laparoscopic cholecystectomy (LC) is the gold standard to treat gallstones. It was introduced by Dubois in 1988 and gradually developed by monitor and video systems [3]. It is about 20 years that LC is practiced in Iran. The following advantages of this surgical procedure have encouraged patients and surgeons toward it: short cuts, short hospital stay, less side-effects, lower post-surgery pain, rapid return to normal activities, and mortality less than 1 % [1, 2].

To obtain satisfactory results, the site of surgery should be clearly viewed during LC; pneumoperitoneum is one of these methods to provide this condition [4]. In this method, CO₂ enters the peritoneal cavity and the pressure kept constant up to the end of surgery, when the ports are removed [5]. The standard pressure in pneumoperitoneum is 12–14 mmHg; it is also associated with complications that usually happen following the prolonged and difficult surgeries due to head-down position and transmission of carbon dioxide to peritoneum (pneumoperitoneum); for example: reducing lung capacity, changes in the concentration of arterial blood gases, hemodynamic complications, increasing liver enzymes, renal failure,

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and increasing post-operative intra-abdominal venous pressure [6–8].

Recently, to reduce the complications, surgeons tend to use gases with 7–10 mmHg pressure instead of the standard pressure. Using lower-pressure gases for the elderly and patients with chronic respiratory and cardiovascular diseases obtain good results. Less shoulder-tip pain and increasing the quality of life after the surgery are other advantages of this method. On the other hand, using lower-pressure gases limits clear viewing of surgical site, prolongs the surgery time, and increases the complications which may lead the surgeon to use standard pressure and open surgery [6, 7].

Considering the advantages of LC, the current study aimed to compare the hemodynamic symptoms and the level of abdominal pain due to using high- and low-pressure carbon dioxide in patients undergoing LC.

Methods

The current double-blind randomized clinical trial was conducted on 60 patients undergoing LC in Velayat Hospital affiliated to Qazvin University of Medical Sciences, Qazvin, Iran, in 2012. The age range of patients was 20–70 years old, and they were randomly categorized into 2 groups of 30. The exclusion criteria were as follows: rupture of gallbladder, empyema, common bile duct stones, patients undergoing extensive upper abdominal surgery, pregnant females, patients with body mass index (BMI) >30 and <19, fatty liver grade 3 and 4, and elevated liver enzymes before the surgery.

In the current study, the pneumoperitoneum with PaCO₂ of 7–10 and 12–14 mmHg were used in the first and second groups, respectively. The standard four-port method, the same surgical method, and general anesthesia were used in the two groups. The same anesthesia protocol was used in both groups. All subjects changed their position or moved, if they could, and started eating 12 h after the surgery. None of the subjects or nurses was aware of the group type.

Abdominal pain at the site of surgery and shoulder-tip pain were evaluated in both groups based on the verbal rating scale (VRS) within 1, 3, 6, 12, and 24 h after the surgery in a way that no pain = 0, moderate pain = 1, medium pain (need one dose of sedative) = 2, severe pain = 3, and intractable pain = 4. The level of nausea and vomiting were also recorded in the groups within 1, 3, 6, 12, and 24 h after the surgery in a way that no nausea and vomiting = 0, slight nausea and vomiting = 1, need for anti-nausea drug = 2, and intractable vomiting = 3. To evaluate the level of liver enzymes such as aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), and bilirubin (BIL), the blood samples were obtained from the patients before and 24 h after the surgery.

The level of arterial blood pressure, heart rate, and body temperature of the subjects were recorded during the surgery and 1, 3, and 6 h after the surgery. Data were collected based on the designed checklists and transferred into SPSS ver. 16. Data regarding quantitative measures and qualitative measures were analyzed by *T* test and Chi-square tests, respectively. To assess parameter changes in the groups before and after the injection, ANOVA and repeated measurement were used. The current study was registered in the Iranian Clinical Trial Registry (code number: IRCT2014121420309N1).

Results

In this study, information of 60 patients was analyzed. In the first group, 22 cases (73.3 %) were females and 8 cases (26.7 %) were males. In the second group, 29 cases (96.7 %) were females and 1 case (3.3 %) was male. According to the results of the current study, there was no significant difference regarding the age (39 ± 13.3 vs. 36.4 ± 15.8 , $P = 0.493$), weight (68.6 ± 7.1 vs. 73.1 ± 8.1 , $P = 0.143$), and height (161.2 ± 4.7 vs. 158.9 ± 7.9 , $P = 0.181$) between the two groups of PaCO₂ of 7–10 mmHg and PaCO₂ of 12–14 mmHg ($P > 0.05$).

There was a significant difference regarding the mean systolic blood pressure at specific intervals between the two groups, comparing the hemodynamic symptoms using repeated measured ANOVA ($P = 0.01$) (Fig. 1). On the other hand, there was no significant difference between the two groups comparing the mean diastolic blood pressure at specific intervals ($P = 0.08$); the means were similar in both groups (Fig. 2). There was a significant difference regarding the mean heart rates at specific intervals between the groups ($P = 0.001$), and the mean heart rate at specific intervals were not similar and the difference was obvious during the surgery and 1 h after the surgery (Fig. 3).

Results of the liver function tests showed a significant difference between the groups regarding all measured factors before and after the surgery, except that no significant difference was observed in the high-pressure group regarding the levels of BIL before and after the surgery. Accordingly, there was a significant difference between the two groups regarding the mean post-operation ALP after the surgery ($P = 0.03$); the means of other factors were similar in the two groups ($P = 0.03$) (Table 1).

The frequency of abdominal and shoulder-tip pain were compared between the two groups at 1, 3, 6, 12, and 24 h after the surgery using Chi-square test. According to the obtained results, there was no significant difference regarding the frequency of pain 1 h after the surgery between the groups; but significant differences were observed between the groups in other assessed time intervals, in a way that the pain grades 3

Fig. 1 Comparing the means of systolic blood pressure at specific intervals between two groups

and 4 were not observed in the low-pressure group at the assessed times (Table 2).

The frequencies of nausea and vomiting were compared between the groups at 1, 3, 6, 12, and 24 h after the surgery using Chi-square test. There was just a significant difference in this regard between the groups at 12 h after the surgery (Table 2).

Discussion

The current study compared the hemodynamic symptoms and the level of abdominal pain using low- and high-pressure carbon dioxide in patients undergoing LC. Results of the current study showed that subjects were similar in both groups regarding age, gender, and weight. There was a significant difference between the groups regarding the mean of systolic blood pressure and heart rate in the same time intervals, in a way that the means of the low-pressure group were lower than those of the

high-pressure group ($P < 0.05$), but no significant difference was observed in the means of diastolic blood pressure between the two groups ($P = 0.08$). The frequencies of abdominal pain and shoulder-tip pain were lower in the low-pressure group, except the first hour after the surgery. There was a significant difference between the groups regarding the level of nausea and vomiting only 12 h after the surgery (0.01). Laparoscopy is a minimally invasive surgery which is nowadays preferred to open surgery. Laparoscopic surgeries are associated with better maintenance of hemostasis compared to open surgeries due to top benefits such as more rapid hospital discharge, less post-operative complications, and lower costs. Also, there is lower post-operative pain in laparoscopic surgeries compared to open ones. Laparoscopy is widely used in many surgeries; one of them is LC [9]. To perform a surgery with better results and avoid a second surgery, the surgical site should be viewed clearly; for better viewing the surgical site, CO_2 is used, in a way that the more CO_2 during the surgery, the better viewing the surgical site. But it is also associated

Fig. 2 Comparing the mean of diastolic blood pressure at specific intervals between the groups

Fig. 3 Comparing the means of heart rate at specific intervals between the groups

with some complications, and accordingly several studies are conducted on using different CO₂ pressures during the surgery for better viewing the surgical site and fewer complications [10].

One of the common complications of laparoscopy is the hemodynamic changes during peritoneal insufflation of carbon dioxide associated with decreased cardiac output, increased systemic vascular resistance, hypertension, heart rate changes, reduced respiratory capacity, and increased airway pressure [11]. Detrex et al. compared the post-operative results obtained from surgeries with 15 and 7 mmHg PaCO₂. Accordingly, they reported that the decreased cardiac output, stroke volume of heart, and heart rate changes in the low-pressure group was much lower than those of the high-pressure group, and both groups had good surgical results. In another study, Kanwer et al. compared the results of two CO₂ pneumoperitoneum pressures, 10 and 14 mmHg, and reported no significant difference between the groups regarding the levels of systolic and diastolic blood pressures, heart rate, and pain, 6 h after the surgery, although the results were lower in the low-pressure group [11]. Although laparoscopy was a modern step toward the surgery quality improvement and lowering its complications, the pain in difficult surgeries still exists and a new step toward controlling the pain can

satisfy the patients. Also, studies showed that in 17–41 % of the patients, the main cause of hospital discharge delay and longer hospitalization within the first 24 h after the surgery was the pain caused by LC, and accordingly the first and main complaint of the patients is about prolonged hospitalization due to LC [12, 13]. In the study by Vesakis that compared the level of pain between the low-pressure and without pressure groups, there was no significant difference regarding the level of abdominal pain between the groups; but because of prolonged surgery, the shoulder-tip pain was more in the high-pressure group [14]. In the current study, the levels of abdominal and shoulders-tip pain were higher in the high-pressure group, compared to the low-pressure one. In the study by Kanwer et al., they reported a significant difference regarding the level of 12 h post-operative pain between the groups; it was lower in the low-pressure group (54.2 ± 8.5 vs. 62.2 ± 12.0). In another study by Al-Dabbagh [10] on the level of post-operative pain in patients undergoing LC, patients were categorized in two groups as low-pressure of 8 mmHg and high-pressure of 12 mmHg. Comparing the post-operative pain between the groups showed that the level of 4, 8, 12, and 24 h post-operative pain in abdomen and shoulders were lower in the low-pressure group, and the significant difference was observed between them ($P = 0.01$)

Table 1 Comparing the mean and standard deviation of liver function test results, before and after the surgery in two groups

	High-pressure		<i>P</i> value	Low-pressure		<i>P</i> value	<i>P</i> value regarding the post-operative level of enzymes between two groups
	Post-operation	Pre-operation		Post-operation	Pre-operation		
AST	37.9 ± 13.3	20.6 ± 6.8	0.001	45 ± 29.1	20.8 ± 7.1	0.001*	0.23
ALT	31 ± 12.2	20.7 ± 13.7	0.001	34.9 ± 15.4	18.6 ± 6.7	0.001*	0.28
ALP	187 ± 78.2	185 ± 63	0.8	147 ± 61.2	169.7 ± 57	0.001*	0.03*
BILLT	0.7 ± 0.2	0.6 ± 0.3	0.008	0.66 ± 0.2	0.61 ± 0.16	0.01*	0.3
BILLD	0.3 ± 0.1	0.2 ± 0.1	0.03	0.3 ± 0.1	0.21 ± 0.05	0.002*	0.7

**P* value < 0.05 was considered as the level of significance

Table 2 Comparing the frequency of subjects regarding abdominal pain, shoulder-tip pain, and the level of nausea and vomiting post-operative symptoms between two groups

Time after surgery	Adverse event	Pressure groups	Score				
			0	1	2	3	4
1 h	Shoulder-tip	Low	4	16	10	0	0
		High	2	8	16	4	0
	<i>P</i> value		0.03*				
	Abdominal	Low	0	4	20	6	0
		High	0	6	12	11	1
	<i>P</i> value		0.18				
	Nausea and vomiting	Low	8	12	6	4	—
		High	5	10	14	1	—
	<i>P</i> value		0.1				
	3 h	Shoulder tip	Low	14	12	4	0
High			2	11	13	4	0
<i>P</i> value		0.03*					
Abdominal		Low	0	8	22	0	0
		High	0	1	19	9	1
<i>P</i> value		0.001*					
Nausea and vomiting		Low	10	12	8	0	—
		High	8	11	10	1	—
<i>P</i> value		0.6					
6 h		Shoulder tip	Low	10	12	8	0
	High		4	10	10	6	0
	<i>P</i> value		0.03*				
	Abdominal	Low	0	16	14	0	0
		High	0	8	17	4	1
	<i>P</i> value		0.04*				
	Nausea and vomiting	Low	16	8	6	0	—
		High	11	10	8	1	—
	<i>P</i> value		0.4				
	12 h	Shoulder tip	Low	20	10	0	0
High			10	8	12	1	0
<i>P</i> value		0.001*					
Abdominal		Low	4	4	22	0	0
		High	0	0	7	22	1
<i>P</i> value		0.001*					
Nausea and vomiting		Low	22	2	6	0	—
		High	7	18	4	1	—
<i>P</i> value		0.001*					
24 h		Shoulder tip	Low	22	8	0	0
	High		16	9	6	0	0
	<i>P</i> value		0.02*				
	Abdominal	Low	8	22	0	0	0
		High	0	24	6	0	0
	<i>P</i> value		0.001*				
	Nausea and vomiting	Low	26	4	0	0	—
		High	21	8	1	0	—
	<i>P</i> value		0.23				

**P* value < 0.05 was considered as the level of significance

[15]; the results of their study are compatible with those of the current study.

Increasing the level of liver enzymes is one of the complications associated with LC evaluated in some studies; in a study by Sayadi et al. on the effect of low- and high-pressure carbon dioxide, compared with open surgery based on the increased liver enzymes, the results showed a significant difference between the first and second groups regarding changing the level of liver enzymes before and after the surgery, but the changes were transient and the rates dropped by passing the time. But in the third group, the changes in AST and ALT were significant only before and 24 h after the surgery and the high rates dropped to initial level after 72 h. However, there was also a significant difference between the first and second groups regarding the level of lactate dehydrogenase (LDH) before and 24 h after the surgery [16]. In the study by Hasuki, the level of increased liver enzymes were compared between the groups of PaCO₂ of 14 and 7 mmHg gas pressure; result of his study indicated that the levels of liver enzymes were significantly higher in the high-pressure group 24 h after the surgery compared with those of the low-pressure group and the rates dropped to the initial level after 48 h [17].

In the current study, the means of liver enzymes after the surgery were higher than those of before surgery in both groups. There was a significant difference regarding the level of ALP between the groups; the mean was lower in the low-pressure group, but according to Sayadi the difference was observed in the level of LDH.

Conclusion

Considering the advantages of laparoscopy and also the necessity for peritoneal CO₂ insufflation for better viewing the surgical site, results showed that using low-pressure CO₂ decreases hemodynamic complications and also the levels of abdominal and shoulder-tip pains in patients compared to those of the high-pressure CO₂.

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Compliance with Ethical Standards

Ethical Statement The current study was registered in the Iranian Clinical Trial Registry (code number: IRCT2014121420309N1).

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Conflict of Interest The authors declare that they have no conflict of interest.

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